The Xtal Set Society Newsletter

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Artillery Spotting with Spark Transmitters and Crystal Sets, 1918, WW1

Phil Anderson, WØXI

Pat and I have exhibited at the 4SQRP Convention in Branson Missouri in late April for at least the last six years. 4SQRP is a fantastic QRP club and the convention is unique in its format of presenting six or more presentations on Saturday on many aspects of amateur radio over the years. This year I met Harold Ingles (NØJUG) at the convention. He stopped by our table and showed me a dark greenish box with a metal label on top titled Signal Corp U.S. Army, Radio Receiving Box, Type BC-14A, October 23rd, 1918. He wondered if we knew anything about it. I said no and we opened the box and began to examining the contents. After a brief discussion, I agreed to tote it home for a look-and-see. The receiver's story unfolds in the following pages. Thanks Harold!

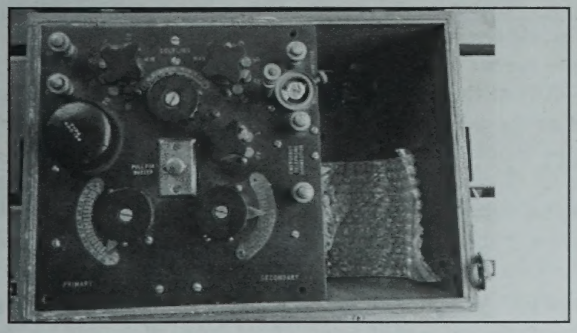

Figure 1: Front View of BC-14A Crystal Set Receiver

It turns out that the BC-14A is a crystal set! With the hinged cover opened, we get a nice view of the set's front panel. Ground and antenna posts are at the upper left; the knobs for the primary and secondary variable capacitors are shown at bottom left and right; the button in the middle is for the buzzer tester; the knob directly above the buzzer knob is for adjusting the position between the antenna and receiver two coils; at top middle are two star-shaped knobs for adjusting coil taps; and, finally at top right is the cup/mount for the galena detector. At bottom right are the posts for the headphone leads. The whole box is 12x9x9 inches and weighs 13 lbs.

The open area at the right is for batteries, headphones and an extra supply of galena rocks and cat whiskers. The glass enclosure for the detector was missing, no doubt broken long ago. Semiconductor diodes (detectors), such as the 1N34, were not available in 1918. The detector of choice at the time was the crystal detector, made up of a hunk of galena and a cat whisker (a bit of thin brass or copper wire/rod). A coherer would have been more difficult to use in that it would have required the addition of a vibrator in the case and likely wouldn't have worked as well anyway.

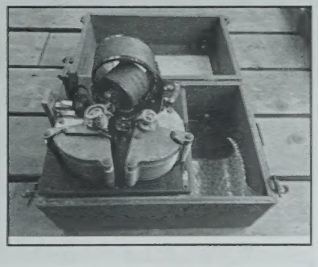

Figure 2: Back Side View of BC-14A Crystal Set Receiver

I removed the receiver from the box and flipped it over to take a look at the components mounted there. The two coils, mounted as a vario-coupler, are shown at the top of the figure 2 picture. Note that the smaller coil has been rotated a bit to the right. Rotation assisted in

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adjusting the amount of coupling between the antenna coil and the main receiver coil. A close look indicated that the wire used was Litz. If so, the Q of the coils would be higher than with conventional wiring. Wiring of the buzzer leads is shown at the center. The two variable capacitors are shown at bottom left and right.

Mounting of the variables was unique. Note that a spiral coil – a few turns – was used to connect the variable (moving) plates of the capacitor to the circuit – as compared with the modern day variable caps that use a copper strip under tension. I used my BK Precision 810C capacitance meter to check these caps out; both – as per the schematic – had a range of 500 pf. Very nice! Finally, note at top and bottom right that the point to point wiring was made with copper strips – no PCBs in those days!

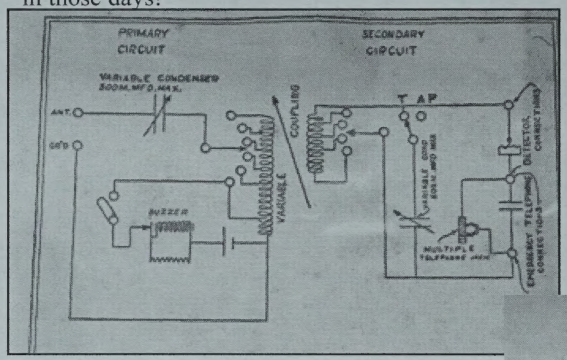

Figure 3: BC-14A Receiver Schematic

The schematic displays a sophisticated crystal set for 1918. Both the primary antenna circuit and secondary detector circuit are tunable. This set was developed for reception in the 500 to 1500 kHz range. Most broadcasts from strong commercial stations during that period were in the 50 to 450 kHz range. Even so, with wavelengths so long, the capacitance of the antenna for this set was high. So, by putting the 500 pf tuning cap in series resulted in an input capacitance over all very near 500 pf or less and therefore depending upon the rotation of the plates of the capacitor. Neat design.

The buzzer was added so that the set could be tested/tuned without a radio signal. The buzzer, not unlike a spark transmitter, created a range of spikes, including that at the frequency of interest. The buzzer was simply a cheap RF test generator. You could use this scheme to build your own in-house cheap spark transmitter.

The secondary circuit – often called the detector circuit – included its own LC tuned circuit, galena detector and headphones. The coil taps and variable capacitor tune to the frequency of interest.

One surprise when opening the box and examining

INSTRUCTIONS

This set is inductively coupled with variable inductance in both primary and secondary circuits. With the condenser connected (switch on T), the secondary circuit will tune sharply, but with the condenser disconnected (switch on AP), the circuit is not tuned and may be used with close coupling as a "pick up" circuit.

The detector may be adjusted for any setting by closing the buzzer circuit switch.

The buzzer circuit is completed through the first ten turns of the primary inductance and excites the antenna circuit when the buzzer switch is closed.

To tune the set to receive a definite wavelength, proceed as follows: 1—Adjust the detector for its best point; 2—Set the secondary circuit at the desired wavelength by refering to the calibration in the lid; 3—Place coupling indicator on 10 degrees or less; 4—Adjust the primary inductance and capacity until the resonance sound is heard in the secondary; 5—The coupling can now be increased, if desired, and slight variations made in the primary and secondary settings to obtain best signals from the sending station.

The sharpest tuning is obtained by using very loose coupling, as much inductance, and as little capacity, as possible in both the primary and secondary circuits.

Figure 4: Receiver Instructions

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the contents was the coated schematic and operating instructions glued on the top of the inside of the box. Since the top tilts to the back, one can look at the schematic and instructions and operate the set at the same time. Nice! Figure 4 is the picture of those instructions. Take a read!

The BC-14A Receiver at work in WW1 in France in 1918.

I scanned the internet for further information on the BC-14A and found a number of stories. This receiver arrived in the field of battle in France in 1918 (during WW1). Several US manufacturers made the same set. The label on Harold's unit stated: Liberty Electric Corp., Port Chester, N.Y., serial number 4417. Some accounts indicated the following. The radio corp was placed near the gunnery batteries and tried like everyone else to hide their presence in one way or another for obvious reasons! Antennas were 100 or so feet long and erected typically with wooden poles. Cabling was run to the radio tent. Some sites used phone lines to report to the batteries command. These sets typically operated at 1000 kHz. Aiming adjustment codes were sent from the biplanes by spark transmitters to the radio corp. These codes consisted of a few letters and numbers sent with CW.

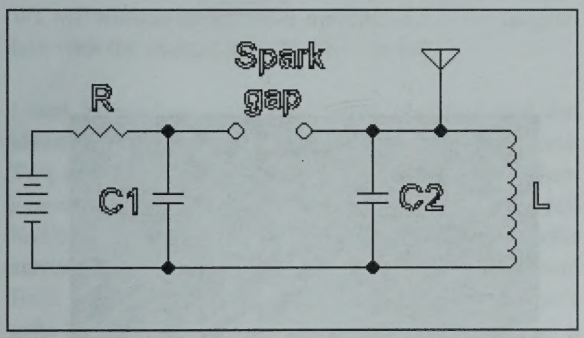

Figure 5: The Spark Gap Transmitter in 1918

A generic schematic for a spark gap transmitter is shown in Figure 5. A picture of an actual unit used in 1918 or there about can be found at www.museumoftechnology.org.uk. The basic arrangement is that a battery – a high voltage DC source – is applied to a spark gap which in turn is attached to a tuned circuit and an antenna. A code key is added in series with the battery to transmit messages. When the key is closed, a voltage builds up on capacitor C1 until it is high enough to create an ark cross the spark gap. The surge in current then energies the L-C circuit which in turn gives up its energy to the antenna. A typical voltage required is at least 280 to 300 volts for a spark gap of roughly 20 mils. Once the spark arcs across the gap the air is briefly removed ending the spark. Once the air rushes back into the gap, another spark commences.... and so on. As a result, many arcs will occur within the duration of one Morse dot or dash sent. This mix contains a range of frequencies, dominated by the tuned circuit at the antenna.

It is interesting that spotting by biplane and the use of the spark gap transmitter in WW1 would not have been possible without Freidrich Pashen's discovery in 1889. His law is a formulation that gives the breakdown voltage between two electrodes in the air (or other gas) based on the pressure and gap width.

For these simple WW1 spotting spark portable transmitters and crystal set receivers, communication distances achieved reliably were just a few miles. This was, however, sufficient for the spotting job. For a few years to follow, commercial spark stations provided thousands of watts to millions of crystal sets around the world. With the advent of tubes, ~ 1920s ~ spark equipment died rapidly, mostly because the spark transmitters put out more unwanted (off frequency) energy than just that intended for a given commercial station frequency.

Spotting Bi-Plane, 1918

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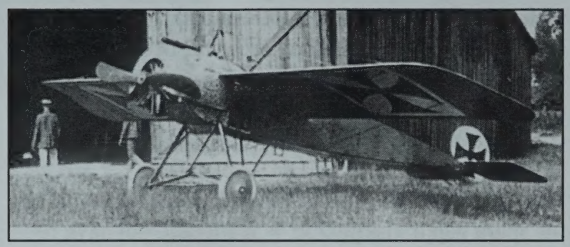
Image the job of the spotting pilot in his biplane. Not only did he have to fly into danger, he had to stuff the batteries and transmitter into the cockpit, pitch an antenna out the back, spot results, and key his message with a code key. In addition to those tasks, he had to watch out for the Fakker Ein-Decker (one-wing fighter) gunning for him.



Das Fakker Ein-Decken German Plane

How to Make an Extension Shaft for a Variable Capacitor Using Nylon Shafts
Xtal Set Society Staff

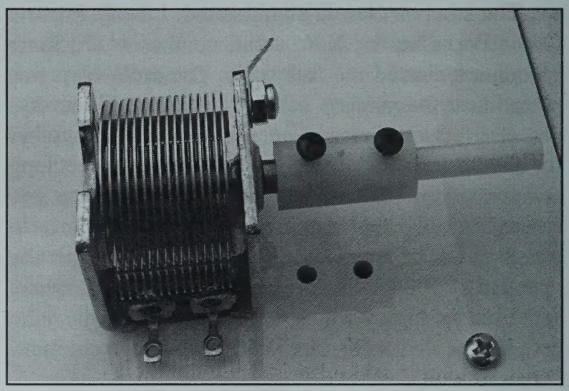
Picture 1 shows two nylon shafts attached to our standard 365 uuf air variable capacitor. One usually adds a shaft if hand capacitance affects your crystal radio tuning or you wish to mount the capacitor inside an enclosure rather than on the front panel. These parts and tools are required:
2, 4-40x3/8 inch Phillips-head screws,
1, 1 inch by 1/2-inch nylon shaft with interior ¼ inch opening,
1, 1.5 inch by ¼ solid nylon shaft,
4-40 drill bit,
4-40 tap bit.

The society stocks the screws and the nylon parts, sold in various assortments. See our current catalog. We do not stock drill and tap bits; see assembly method below.

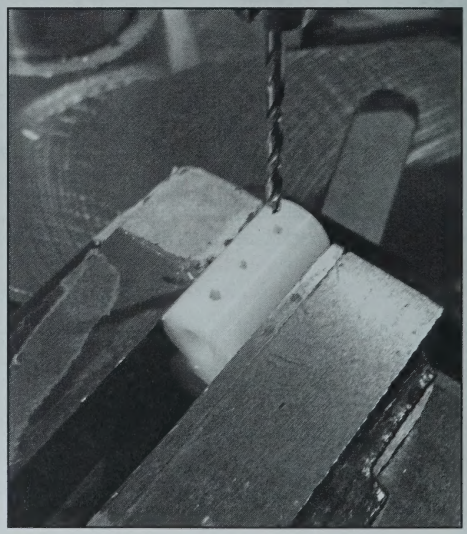
The 1-inch nylon shaft has a quarter-inch opening end-to-end which accepts a portion of the ¼ inch shaft of the capacitor and a portion of the ¼-inch nylon shaft. In order to secure the nylon shafts, two 4-40 holes must to be drilled and tapped in the ½-inch shaft. This will require the use of a 4-40 sized drill bit and a tap bit. These are available in most hardware stores and are inexpensive.

If you've never done this before, you'll find it easy enough, as shown in Picture 2. Mark the 1/2-inch diameter nylon shaft a quarter of the way in from each end. Then secure the shaft in a vice and drill two holes as shown. Then replace the drill bit with the tap bit and re-drill each hole again (using a slow speed), thus adding threads to each hole. It is only necessary to drill the holes on one side of the shaft.

You last step, of course, is to attach the nylon shafts to the shaft of the capacitor and secure all with two 4-40 by 3/8ths screws.



Picture 1



Picture 2

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Why Radio?
by Ken Ladd

When we moved to our farm at Hinckley Minnesota in 1953 we had REA power but no telephone or running water. We had the Motorola Bakelite radio that had been purchased when power came to the previous farm in 1948.

The radio provided news, weather, and entertainment and oh yes the farm market reports for dad. The dial probably never changed from WCCO until the WCMP the Pine City station came on line. When my brother Merlin and I got a little older we were a little more adventurous.

When I saw the Rocket crystal set on a cereal box I asked dad if I could get it. His reply was "it probably wouldn't work". When the Ward's or Sear's Christmas (1958+-) catalog came out I asked for a small radio that cost $2.88. Low and behold they bought it for me. It was basically a rocket radio in a plastic box. I hung wire somewhat precariously out of my second floor bedroom window to secure a ground connection to the bare copper ground connection to the power line weather head. I was able to receive both WCCO and WCMP without an antenna. I still have it in the original box with the instructions and the receipt.

I was hooked on radio and when people found out about it they gladly gave me all their unwanted sets. Two memories stand out for me. A coil of wire from a speaker that my cousin Curt gave me and a D cell battery produced a spark that could be heard in a radio across the room. Many years later I learned about Back EMF. I unwound many a capacitor from Curt's gifts and saved hardware. Sometime later I fired up a "new" Bakelite radio after having blown the dust out of it as I was babysitting my younger siblings. I could not understand why one particular station kept saying that it was 11:30. I eventually figured out that it was WDGY. The song they played a lot was A Thousand Stars In The Sky. Years later I learned that it had been sung by Brenda Scott.

When my cousin Wally went into the Army he passed some of his goodies onto me. There were some radios and two sets of Brandees headphones. One of the radios was a small wooden Firestone radio with two shortwave bands. I climbed a Pine tree opposite my bedroom window and strung some flat TV lead in wire for and antenna. Not knowing what I was doing I turned every adjustment in the set for peak performance. One night after I had twisted and turned everything to no avail I figured out that rain had shorted the lightning arrestor and I had to start from scratch. I hooked the headphones to the speaker so I could get by listening late into the night. There was The Shadow and The Green Hornet on WHO, Ralph Emery's opry Star Spotlight show on WSM and of course the Opry. I dx'd the broadcast and shortwave bands. I will never forget Radio Havana's "Free territory of America". One night I was listening to one side of a ham conversation of a ham from Hannibal Missouri. After having sounded kind of odd, he said that he had just experienced an earthquake tremor. He gave his address to the other ham. My first QSL card! I also received confirmation from some broadcast stations.

I went one to study Electronic Technology at St. Paul Vocational School after high school in 1965 all the while experimenting with crude crystal sets and the innards of a Philco console radio. More QSL cards.

After a very short stint (medical discharge) I was hired at Control Data in May of 1969 and kept that job until retiring after 44 years and age 66. I built a couple of Modern Radio Laboratories radios and listened to a couple of factory radios but was not very active until I became a member of the Northland Antique Radio Club (NARC). My love for building adventuresome projects has bloomed over time.

I have been collecting crystal radio plans and articles since high school and hope to put what I have on a disk so I can share what I have.

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Xtal Corner: Member Correspondence

Dear Phil and Pat,

I enjoy reading the Xtal Set Society newsletter. I get a lot of good ideas out that fine publication. I always look forward to receiving my next newsletter and I also like your web-site. Keep up the good work!

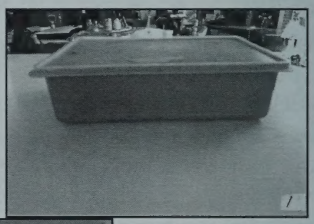
The Xtal Set Society has managed to revive old and fond memories of when I first got bit by the "radio bug". My aunt Flora wanted to swamp out the cellar one day and among the articled that she wanted to get rid of was a PHILCO #41~280 all-wave console radio from the early 1940's. She offered it to me and I took it home with the help of Dad. It had three bands and they were the AM band and two short wave bands. I had a lot of fun tuning the short wave frequencies with that radio. A couple of years later, I started experimenting with crystal-sets with scrounged magnet wire and derelict radio parts from germanium diodes to pnp transistors to ceramic and air-variable capacitors and earphones, etc.

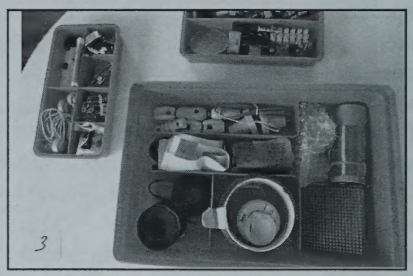
As the years went by, I got my Associates in Science degree in Electronics Technology and went into industrial electronics and then into sales later on. A couple of years ago, I stumbled across your Midnight Science web-site and my interest in crystal sets got re-ignited. I have been a SWL since 1965 and a HAM since 1991. However, I consider myself more of a SWL than a HAM.

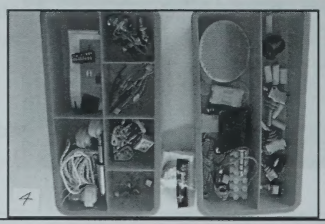
At any rate, one of the main reasons that I wanted to write this letter was to share with you an idea that I had and that was to make up a parts kit out of an old Tupperware container that I had on hand. The container consists of electronic parts, wire and hardware that is dedicated to the design and building of crystal sets and other basic receiver for use on the AM or short wave bands.

Enclosed, along with this letter, are four photographs of the above-mentioned parts kit. As you can see, it holds magnet and hook-up wire, insulators, earphones, knobs, transistors, germanium diodes, FETs, capacitors, resistors and other assorted stuff. The Tupperware container keeps everything reasonably neat and organized and it can easily be tucked away when not in use.

I guess that is all for now. At some point, I'll send you pictures of some of my radio projects.







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Hi- I am looking for an air variable capacitor with reduction drive for use on a magnetic loop antenna. I intend to use this to transmit around 10 watts of power but may want to go higher if possible. Do you know the voltage rating of the capacitor Part # 365-8-1? I think I need one that can handle 2000 volts. The one I have now arcs over at only 5 watts.
Thanks
Joe Volkel - N4CPQ

Hi Joe,

Our capacitors have a gap of about 15 to 20 mils between plates. As such they are not suitable for high power. Look up Paschen's Law on the internet. Here's one source:
https://en.wikipedia.org/wiki/Paschen%27s_law

For a 20 mil gap the voltage is roughly 280 to 300 volts.

73, Uncle Phil, W0XI
4sqrp member.

From Bart:
Good evening,
I am a proud owner of the Ultra-RX1 and recently ordered the Ultra-RX3. I noticed that the DIL IC's in the RX3 kit are supposed to be soldered directly onto the PCB and do not use IC sockets. Is this for reasons of electronics circuitry or could I use sockets for the IC's without a change in RX3 circuit characteristics?

Thank you for your response and best regards,
Bart Tichelaar - KE5GUR

Hello Bart,

It's a matter of personal preference. My experience has been that the sockets tend to rust after a bit and become intermittent. This varies by vendor. If you wish to use sockets, get good ones. Cheap price generally means earlier rust. Assuming that the sockets are good, there is no reason electrically why they would fail or affect performance.

Glad you enjoy the RX1. I've had a lot of fun listening to Bats and bugs in the grass, etc, with both my RX1 and RX3. Fun stuff. Best time to listen for Bats is about 7 PM in the evening during the summer.

Some locations have folks that put up bat houses.....and that would be a good place to visit. During August is a good time to listen to what lives in your front lawn.....beetles, bugs, etc speaking their minds: eek eek eek.....most interesting.
73, Phil Anderson, W0XI Look for me on 20-meter CW, usually mornings around 14030 through 14050 ish.

Thanks much Phil for your response. I find it very fascinating that you designed a project that uses "radio technology" to transform ultrasonic sound to audible. Never thought about this possibility until I learned about it at MidnightScience. I will look for you on 20 m once I am set up again with a 20 m antenna. Best regards, Bart

From Bernie:
Uncle Phil, just wanted to let you know that I have completed the assembly of the board. I am waiting for my grandson so we can work on bolting it together. He is a bit young for the soldering work but he got all the resisters in.

Since it was up and running, I used it and want to say the sounds and quality blew me away! I heard all sorts of sounds just in the house. When I went out with it last night, I heard this woshing sound as I walked though the lawn. Turns out it was my feet on the grass! How cool is that.

Hope the kid likes it...we are taking a "bat tour" on the Waugh Bridge. You can walk right up under the bridge where they are living in the support beams. It is a nightly event as they leave.

Anyhow, thanks for a great kit.
All the best Bernie N5TES

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From Walt:
Hi
Can I use the 2n5486 ,which you sell, in place of the mpf102?

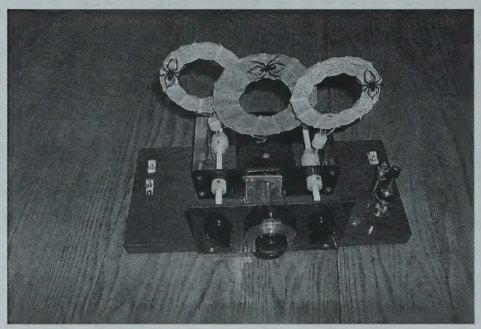
Walt Tukkanen

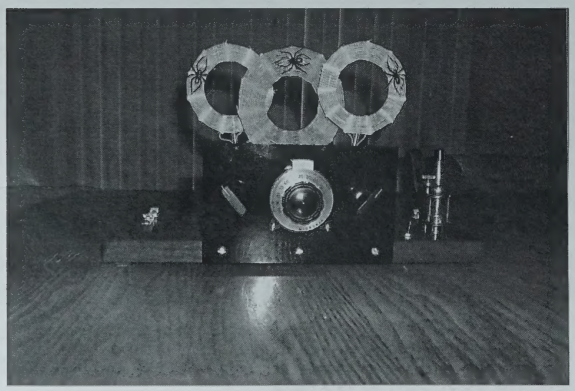
Hi Walt,

In general YES. Looks like the pinouts and packaging are the same; just checked.

73, Phil, W0XI

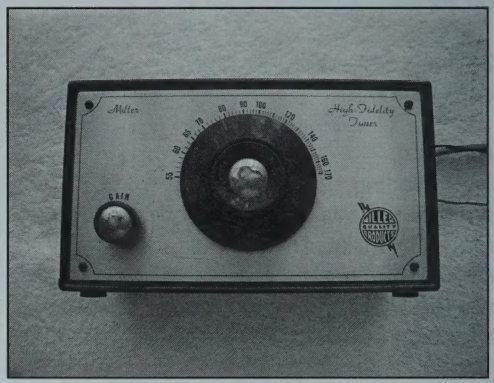
From Larry Jeffers
Just in time for Halloween! The "Arachnoid Crystal Set" complete with swinging spiders on their webs.

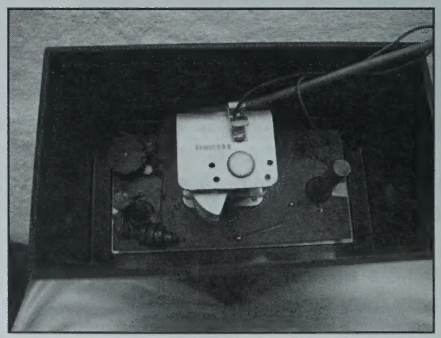




Hello Crystal Set Society...As per my phone call today on 6/10 I'm attaching these pix of my Miller unit... maybe you can sell it and make a little profit which can be contributed for your group, I saw a similar unit for 200 dollars..you can send me the postage...ok ??..the xtal used in this unit is the same type used in my large search RADARS in the receiver section ...I also used Iron Pyrites sulfide fools gold as a detector which I got from Penna coal mines ...We had a bootleg anthracite mine but don't tell anybody...I live in military home....Bernie Bacheson, I m not running for presidents office.

From the Queen: If anyone out there is interested in this radio, let me know and I will connect you to Bernie. He should get the funds for it.





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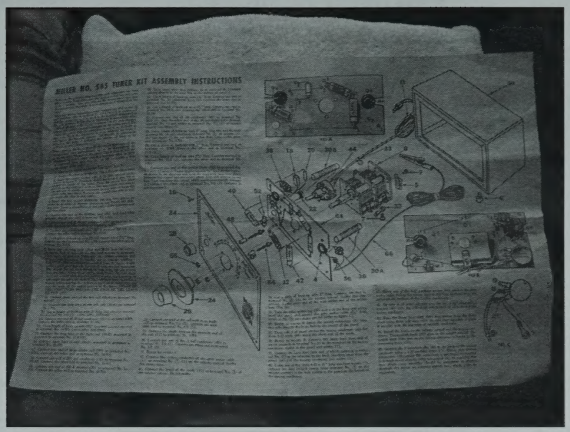
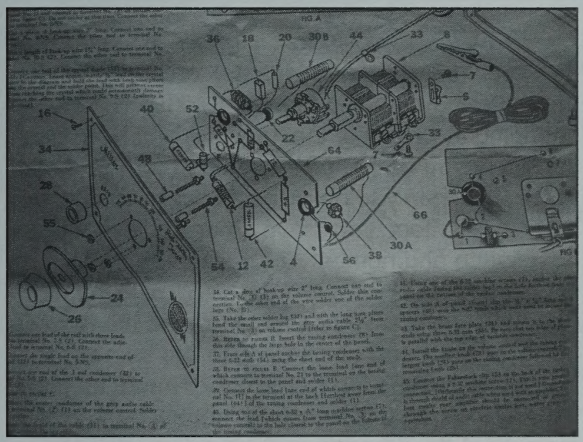
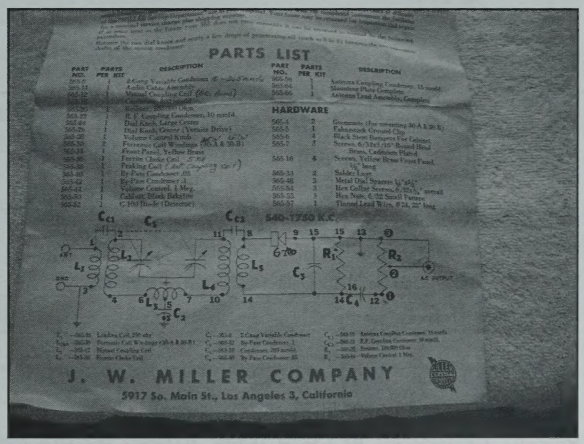
ASSEMBLY AND WIRING INSTRUCTIONS
FOR THE
Miller
NO. 565 MILLER HIGH FIDELITY GERMANIUM DIODE BROADCAST BAND TUNER KIT


MILLER NO. 565 TUNER KIT ASSEMBLY INSTRUCTIONS




PARTS LIST

PART NO.	PARTS PER KIT	DESCRIPTION
565-1	2	Grommets (for mounting 30-A I.F. Units)
565-2	1	Fahnestock Ground Clip
565-3	1	Black Steel Escutcheon For Control
565-4	1	Screws, 6-32x1/16" Round Head Brass, Cadmium Plated
565-5	1	Screws, Yellow Brass Front Panel Type
565-6	4	Solder Lugs
565-7	2	Metal Dial Spacers (1/4")
565-8	1	Hex Collar Screws, 8-32x1/4" overall
565-9	1	Hex Nuts, 6-32 Small Pattern
565-10	1	Tinned Lead Wire, #24, 22" long

HARDWARE

J. W. MILLER COMPANY
5917 So. Main St., Los Angeles 3, California

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Two Excel Spread Sheet Formulas Have been added to our website,
www.midnightscience.com/formulas

$$L = \frac{r^2 N^2}{10l + 9r} = \frac{r^2 N^2}{10Np + 9r},$$

Picture 1: Coil Formula

$$f = \frac{1}{2\pi\sqrt{LC}},$$

Picture 2: Frequency Formula

These two calculators are handy when designing and/or experimenting with crystal sets and other RF projects. The coil calculator is shown in two formats. The first assumes that the coils of the wire are wound snugly side by side. The second includes the pitch (spacing) of the wire when working with single layer coils that are not tightly wound and where N is the number of turns of the single-layer coil.

Inductance for coils is generally measured in micro-henry (uH) while capacitance values are usually measured in puffs (also written as pf). A typical coil – the most common used for HF crystal sets – is 250 micro-henry, uH. For tuned circuits, the capacitor is generally an air-variable, and provides capacitance values from roughly 25 to 400 pf, as is our standard 365 cap found in our catalog. These can be found at http://www.shopping-cart.midnightscience.net/t/capacitors

For the calculator shown in Picture 1, one generally enters the radius, length and number of turns to obtain the inductance value of the coil. For example, if the radius is 1.75 inches (half the width of the coil), the length is 3 inches and the number of turns taken is 61, the inductance of the coil will be about 250 micro-henry (uH).

Sometimes the Inductance is known or desired; then, that value, the number of turns, and the radius can produce the length of the coil.

Our Coil Formula Can Work Four Ways, Sort Of.

Note that the formula, as written, solves for the inductance in micro-henrys (L), given that you plug in the radius (r), length (l) and turns N) for your coil. Keep in mind that the radius is ½ the diameter of the coil. However, you might want to solve for one of the other parameters – say you wish to know the turns (N) by entering the inductance (L), the radius r, and length of the coil (l). YOU CAN STILL USE THE COIL FORMULA as written by using a slight of hand.

Here's how you do it. Enter radius (r), length (l) and an arbitrary value (guess) of the turns (N) and note the resulting inductance (L). Then keep changing the value of the turns (N) until you reach the value you had in mind all along for the inductance (L). Then you have the answer you desired; that is in effect you have your radius, length, inductance and number of turns.

Keep in mind that you could rearrange the formula using algebra and come up with the same result. You can use the above slight-of-hand to solve for any one of the four parameters by knowing (selecting) the other three for the formula.

For the calculator shown in Picture 2, one inserts the L and C values to obtain the resonance frequency of the LC combination, usually called a tuned circuit. This formula is sometimes handy when you have a frequency, and a capacitor in mind and wish to calculate for the inductance or vice-versa. In these cases, you can apply the slight of hand used in the picture 1 formula.

If you wish to see a few other calculators in this spreadsheet format let us know.

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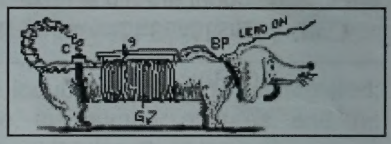

We are dedicated to once again building and experimenting with radio electronics, often—but not always—through the use of the crystal set, the basis for most modern day radio apparatus. This newsletter helps support our goal of producing excellent quality technical books that encourage learning and building. To join the society and receive one year of the bi-monthly newsletter, remit $14.95 to The Xtal Set Society. Canadians, please remit US $15.95. Outside the US and Canada please remit US $21.95.

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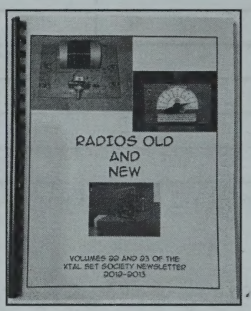
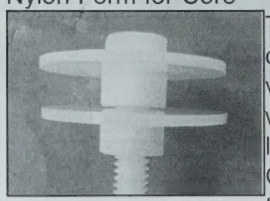


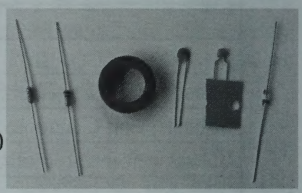
RADIOS OLD AND NEW is volumes 22 and 23 of the Xtal Set Society Newsletter. A wide range of topics and projects are covered in 2012: aerials circa 1917, experiments with regens, grounding and reducing noise in your station, experimenting with spider coils, a 2 for 1 regen set, primer for the 602 mixer at 40 kHz, a modern TRF AM receiver. The following topics for 2013 are: JFET Drain-Output set, a foxhole radio, feedback for beginners, a modern day regen, the universal crystal set, The Albert Hull Memorial Dynatron Regenerative Receiver, adding absorption wave traps, from telegrapher to coherer, a 700 Hz oscillator featuring a quadrature architecture, and more. Vol 23 $15.95

Nylon Form for Core



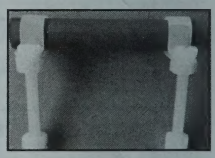
These nylon plastic pieces combine as a form for the various ferrite toroid coils we offer. The form is low loss thus preserving the Q of the coil wound on the form. Extending them above the chassis - which might be metal or fiber board also preserves the coil Q. nycorefrm $2.50

R-L-C-D Assortment



This assortment has nearly all the parts to build a basic am crystal set: 100 pf cap, 330 pf cap, am-band toroidal coil form (ft-82-61), 47k and 100k resistors and a 1n34 diode. RLCD 5.95

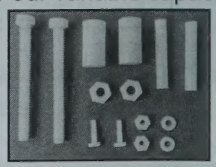
Nylon Form for Rod



This set of nylon parts combine as a form for the ferrite rod, thus preserving the Q of the rod mounted above a chassis. The Rod is not included. Nylon Form rod $2.50

Nylon Assortment

This nylon assortment includes two each of the following: 0.25 by 2.5 inch bolts and 0.25 hex nuts; 6-32 by 0.5 inch screw with 6-32 hex nuts and two 6.32 washers; two 0.5 by 1 inch standoffs (with 0.25 through hole, and 0.25 by 1.5 inch standoffs. the latter two can be tapped and connected as a shaft extender for our variable capacitors. Nylassort $3.50



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